© 2017 IJSRST | Volume 3 | Issue 8 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

GPS Receivers and Integration of GPS/GIS Technology

Nameeta Devi
Assistant Professor, Department of Geography, Indira Gandhi University, Meerpur, Haryana, India

ABSTRACT

The present study shows that GPS is a powerful tool providing a unique position of a specific feature. With this information, one can navigate back to it. However, one cannot relate this “feature position” to any other “feature position” unless one is standing at the site and other features are visible. GIS by itself provides great analysis capability but to achieve that one needs plenty of good data. As explained earlier, some data is available but a lot of other data needs to be collected to allow the full capabilities of GIS to be utilized.
Keywords : GPS, GIS, Satellite, Integration, receiver

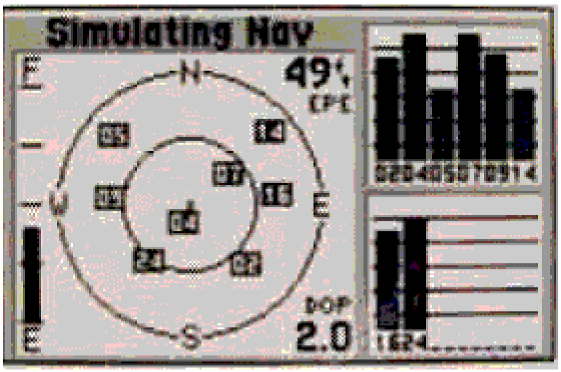
I. INTRODUCTION

Working of GPS Receiver

This is a handheld device weighing about 8 ounces and measuring about 6 inches by 2 inches (ignoring the antenna). The antenna is the vertical stub on the right, roughly three inches long. This unit has a small LCD screen and a set of buttons to activate its different features. When you turn on a GPS receiver, its first task is to try to find the radio signals for the satellites it can “see”. GPS satellites live in very precise orbits about 11,000 miles up (for comparison, the space shuttle orbits at about 200 miles and geosynchronous satellites orbit at about 24,000 miles). Because the satellites are so far away, their radio signals are fairly weak.

Figure 1 : GPS Receiver

Therefore, for the GPS receiver to “see” a satellite, the satellite must be above the horizon and unobstructed by buildings, mountains, etc. At any given moment at any point on the planet there are between 6 and 9 satellites above the horizon. During the process of acquiring the satellites, the GPS display will look something like this:



On this screen, the larger circle represents the horizon and smaller circle represents 45 degrees. The dot in the centre is straight overhead. The numbers within the circles represent satellites that are visible, and the bar chart on the right represents the relative strength of the signals from the different satellites. Once the GPS receiver has locked on to 3 satellites, it can display your longitude and latitude to about 100 foot accuracy. If the receiver can see 4 satellites it can also tell you your altitude. With this information you know exactly where you are. Most modern GPS receivers are able to store your track. As you move, the GPS periodically stores your position in its internal memory. It can then show you the path you have followed on the display so that you can see exactly where you have been. Tacks also make backtracking easy. Most modern GPS receivers also support the concept of waypoints and routes. A waypoint is a specific point (longitude and latitude) that you have stored in memory. A route is a series of waypoints connected together to form a path from one point to another. The user can imagine that if you are a boater, he might mark certain buoys as waypoints, or store the coordinates of your favourite fishing spots as waypoints. A hiker might store different landmarks or resting points along a trail as waypoints. The user can then string a collection of waypoints together into a route. At the start of a trip you tell the GPS receiver which route he wants to follow. The receiver will then tell you the heading you need to take to get to the next waypoint in the route. As the user passes each waypoint, the GPS receiver gives the heading to the next waypoint on the route. Some of the newer receivers, like the GPS III shown above, have road maps stored in memory. The unit is therefore able to show the user exactly where he is on a map of the area. Internal maps usually show major highways. By hooking a GPS up to a laptop computer the user can locate you on very detailed road or topographic maps loaded from CD-ROMs. So over all the GPS receivers helps the user to:

- See exactly where the user currently is
- See exactly what path the user has followed using tracks
- Store and then get back to a place the user has visited using waypoints
- Get from point A to point B using waypoints and routes

GPS receivers are especially useful in environments where it is easy to get lost: on the ocean, in the woods, in the air flying at night, etc.

II. METHODS AND MATERIAL

2. Types of Receivers

2.1 Aviation

Airborne GPS receivers are generally used for navigation and attitude determination. There is a wide range of receivers available to fit every budgetary requirement. There are handheld GPS receivers available, which can accept data cartridges containing Jeppson charts. High-end GPS units are being built into jumbo jets and are being tested for automated landing.

2.2 Computer Boards

These receivers are designed to fit inside a computer of some sort. A general purpose IBM-PC based receiver is made by Novatel while another GPS designer kit is made by GEC-Plessey.

2.3 Handheld

Quite a variety of these are now available. Many are intended to fit a specific purpose such as land navigation, boating, aviation and even industrial mapping. The range of features is therefore, fairly diverse. Some are available at prices as low as $300 with some high end-mapping units running up to $4000.

2.4 Mapping

These receivers are intended for mapping items for later inclusion in databases, maps or drawings. All will have DGPS capability and most will have the ability to store lots of points and add text or menu information to the points. These units will start around $1000 and go up from there.

2.5 OEM Modules

OEM modules are bare GPS receiver boards that are intended to be incorporated into other equipment. Many will be outfitted with one or two RS-232 ports from which the user is responsible for programming the unit and interpreting the output. These can run from a few hundred dollars to several thousand dollars.

2.6 PC Card (PCMCIA)

There are only three of these: The NavCard is made by Rockwell while Trimble Navigation makes the GPScard and the Gold GPScard. The Gold card accepts differential correction while the regular card does not. All of these cards are priced between $300 and $1600.

2.7 Marine

These are used almost exclusively for navigation. Many will have NMEA-183 interfaces for connecting to other ship electronics.

2.8 Space borne

Space born GPS receivers are used for satellite navigation and attitude determination. Most space borne receivers are radiation-hardened versions of ground-based receivers.

2.9 Surveying

This grade of receiver is used by surveyors to derive "measurements" rather than "position". For surveyors it is the relative relationship between two receivers that is important; from this relationship an absolute "position" may be derived if and as necessary, on whichever datum is appropriate for the survey. Surveying receivers are generally capable of the highest accuracies and cost the most (up to $30K per set).

3. Error in GPS

Up to now we've been treating the calculations that go into GPS very abstractly, as if the whole thing were happening in a vacuum. But in the real world there are lots of things that can happen to a GPS signal that will make its life less than mathematically perfect. To get the most out of the system, a good GPS receiver needs to take a wide variety of possible errors into account. Here's what they've got to deal with. First, one of the basic assumptions we've been using throughout this tutorial is not exactly true. We've been saying that the user calculates distance to a satellite by multiplying a signal's travel time by the speed of light. But the speed of light is only constant in a vacuum. As a GPS signal passes through the charged particles of the ionosphere and then through the water vapor in the troposphere it gets slowed down a bit, and this creates the same kind of error as bad clocks. There are a couple of ways to minimize this kind of error. For one thing we can predict what a typical delay might be on a typical day. This is called modeling and it helps but, of course, atmospheric conditions are rarely exactly typical. Another way to get a handle on these atmosphere-induced errors is to compare the relative speeds of two different signals. This "dual frequency" measurement is very sophisticated and is only possible with advanced receivers.

Trouble for the GPS signal doesn't end when it gets down to the ground. The signal may bounce off various local obstructions before it gets to our receiver. This is called multipath error and is similar to the ghosting you might see on a TV. Good receivers use sophisticated signal rejection techniques to minimize this problem. The whole concept of GPS relies on the idea that a GPS signal flies straight from the satellite to the receiver. Unfortunately, in the real world the signal will also bounce around on just about everything in the local environment and get to the receiver that way too. The result is a barrage of signals arriving at the receiver: first the direct one, then a bunch of delayed reflected ones. This creates a messy signal. If the bounced signals are strong enough they can confuse the receiver and cause erroneous measurements. Sophisticated receivers use a variety of signal processing tricks to make sure that they only consider the earliest arriving signals (which are the direct ones).

3.1 Problems at the satellite

Even though the satellites are very sophisticated they do account for some tiny errors in the system. The atomic clocks they use are very, very precise but they're not perfect. Minute discrepancies can occur, and these translate into travel time measurement errors. And even though the satellites positions are constantly monitored, they can't be watched every second. So slight position or "ephemeris" errors can sneak in between monitoring times.

3.2 Ephemeris Errors

Ephemeris (or orbital) data is constantly being transmitted by the satellites. Receivers maintain an "almanac" of this data for all satellites and they update these almanacs as new data comes in. Typically, ephemeris data is updated hourly.

4. Correcting Errors

- ✓ The earth's ionosphere and atmosphere cause delays in the GPS signal that translate into position errors.
- ✓ Some errors can be factored out using mathematics and modeling.
- ✓ The configuration of the satellites in the sky can magnify other errors.
- ✓ Differential GPS can eliminate almost all error.

Basic geometry itself can magnify these other errors with a principle called "Geometric Dilution of Precision" or GDOP. It sounds complicated but the principle is quite simple. There are usually more satellites available than a receiver needs to fix a position, so the receiver picks a few and ignores the rest. If it picks satellites that are close together in the sky the intersecting circles that define a position will cross at very shallow angles. That increases the grey area or error margin around a position. If it picks satellites that are widely separated the circles intersect at almost right angles and that minimises the error region. Good receivers determine which satellites will give the lowest GDOP.

Summary of GPS Error Sources

Table 1: GPS Error Source

Typical Error in Meters(per satellite)	Standard GPS	Differential GPS
Satellite Clocks	1.5	0
Orbit Errors	2.5	0
Ionosphere	5.0	0.4
Troposphere	0.5	0.2
Receiver Noise	0.3	0.3
Multipath	0.6	0.6

III. RESULTS AND DISCUSSION

6. How is accuracy improved?

6.1 Differential GPS

In order to achieve on-line positioning with high accuracies, Differential GPS (DGPS) is used. Differential positioning user the point position derived from satellite signals and applies correction to that position. These corrections, difference of determined position and the known position, are generated by a reference receiver, whose position is known and is fed to the instrument, and are used by the second receiver to correct its internally generated position. This is known as Differential GPS (Figure-2).

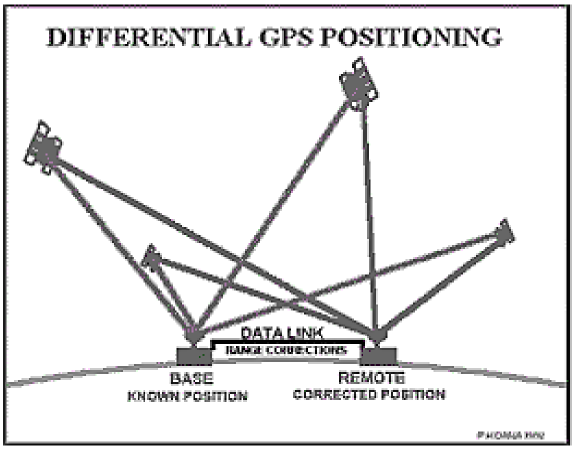


Figure 2 : Differential GPS (DGPS)

The principal of DGPS is simple. If 2 receivers are placed close to one another, around 100-200 kms they will be subject to the same amount of errors and travel through the same atmospheric conditions. So one uses 2 receivers- one at a known point (base) while the other receiver is collecting the data in the field (rover). The base receiver at the known point stores the position data in the memory or on a PC, while the rover stores the data from the field in its onboard or external memory. The computer compares the second by second data from GPS unit at the base with the actual known point data at the base station and determines the amount of error. When the data from the rover is downloaded in the PC, the software applies the corrections to the rover data and corrects the rover readings. This method is called the post processing method. This method, while providing good accuracy has some limitations and disadvantages:
One needs 2 receivers (thereby raising the cost) or access to some base station data from a location within 200 kms from the rover.

- This method also does not provide you with real time navigation capabilities.
- Frequently, if the satellites tracked by the base and rover units are different, the readings will not be corrected.
- The other factor to consider in this method is the fact that for every hour spent in the field to collect the data, one needs to spend about an hour in the office post processing this data.

Instead of using the post processing method, one can now utilize the real time correction method. In this case instead of storing the base station data and processing on the PC, the error is calculated in the receiver at the base and broadcast. The U.S. Coast Guard offers one such system and if one has a GPS receiver with an appropriate beacon receiver, one can receive the corrections in real time and accurate GPS readings are displayed. While the service is free, it has a limited range. This range is heavily dependent on the topography of the area. Therefore, this is not a solution for everyone. The second real time system is offered by private companies who are transmitting the correction signals from a satellite. This allows for far better coverage all over the world. But the service ranges around $800.00 to $5,000.00 per year for various areas in the world. Monthly service is also available. The last 2 methods offer the capability of real time accurate readings and therefore good navigation capabilities. Also one does not have to spend time in the office to correct the field data.

7. Integration – GPS/GIS Technology

Combining the GPS data with GIS allows for greater capabilities than what GPS and GIS can provide individually. With the combination of two technologies one is able to display the "FIELD/ACTUAL SITE" on a PC and make informed decisions. There is no need to make specific site visits or review several documents/drawings. Also, another benefit of the integration is the fact that the data can be shared by unlimited users in various departments for their own specific needs and analysis.

Another important advance in this technology has been the introduction of software which allows bringing into GIS not only GPS position information but a digital picture. With this software, one can study relationships between features but also view actual photographs of the features right on your PC.

8. Pitfalls of Integration

Combination of GPS/GIS technology is limited by the amount of data. As explained earlier one needs lot of good data for conducting analysis. While some data is available, a lot of data has to be generated by the users for their use. Sometimes collection of field data could turn out to be time consuming and expensive. Data collected must be accurate and meet the correct formats. For example one need to make sure that all the "layers" of data displayed are in same units (feet/meters) and the projections and datums match. Without this the analysis will not be correct.

9. Application in Forestry

9.1 GPS surveying applications:

- ✓ Pre-Harvest & post-harvest cut block traversing
- ✓ Road systems & landings
- ✓ Mechanical site preparation
- ✓ Juvenile spacing, mechanical brushing & planting
- ✓ Forest health (ie) insect & disease tracking
- ✓ Forest fire monitoring
- ✓ Research plots

GPS is used in a wide range of activities such as navigation, tracking, positioning, and precision timing, in all sorts of technology sectors. By integrating the navigation, positioning, and timing abilities of GPS with other technologies and data collection, electronic displays, and communications, a vast amount of applications can be created. In forestry there are no shortage of uses. Large game tracking, vehicle dispatch, heavy equipment monitoring, and all sorts of field data collection application have already been initiated. GPS has been rapidly evolving over the past few decades. This moving target is sometimes hard to keep up with: dropping prices, new features, Selective Availability (ON then OFF, On and now OFF again), Differential GPS Sources (beacons, satellites, the internet, Bulletin Boards, Wide Area solutions), Dual Frequency, Single Frequency, military bands civilian bands, code and phase processing. GPS can be used to create and maintain digital map databases for the forests we manage. Field digitizing silviculture features, wildlife habitats, cultural and infrastructure features are partly collected on foot. Fire spotting and areal spraying use GPS in aircraft. Field biologists and sport fishers use "fish finders" with integrated GPS units. Forestry applications that use GPS are continually changing. Simple field digitization and differential processing is a good start, but individuals with knowledge and experience across the wider spectrum of GPS activities increase their appeal to forest companies and organisations. GPS technology offers several advantages:

First and foremost, the service is free worldwide and anyone with a receiver can receive the signals and locate a position. Second, the system supports unlimited users simultaneously. Third, one of the great advantages of GPS is the fact that it provides navigation capability.

10. Limitations of GPS

As with any technology, GPS also has some limitations. It is essential that the users are aware of these limitations. One must recognize that a GPS receiver gives a location reading, which is subject to some inherent errors some under our control and some outside our control. Unless specific steps are taken to improve the accuracy, even with the Selective Availability (SA) off stand-alone receivers can be as much as 15 meters off. In order to obtain a GPS position reading, one needs to occupy the point. Often one cannot get there (maybe you don't want to cross a highway with heavy traffic) or you do not want to get there (wildlife etc.).With GPS, if you cannot occupy a point, you cannot obtain the GPS reading. Even if one can reach the point, the area may be covered with a canopy (thick forest) where GPS signals cannot reach and therefore cannot get the reading. GPS needs clear view of the sky. The elevation readings from GPS receivers are not very accurate. Even with differential GPS, the elevation readings can be 2 to 3 times worse than horizontal readings.

IV. CONCLUSION

The integration of GPS with GIS brings the real world to the desktop. What could take days to visit a specific site and analyze can now be performed on the desktop. The power of GPS/GIS is immense and application are unlimited and varied in all areas such as agriculture, environmental, defense, natural resources, health, business etc. As the price of hardware and software comes down the potential of this integration to grow tremendously in country like India. Use of this technology has tremendous application in forestry sector. Use of GIS/GPS & Remote sensing is now being incorporated to prepare the working plan of forest divisions. The tremendous potential of this integrated technology is getting explored in recent times.

V. REFERENCES

[1]. www.aero.org/publications/GPSPRIMER
[2]. www.cnde.iastate.edu/gps.html
[3]. www.colorado.edu/geography/gcraft/notes/gps/gps_f.html
[4]. www.garmin.com
[5]. www.gpsworld.com
[6]. www.magellangps.com
[7]. www.trimble.com